1894

Domestic and commercial fertilizers: results of five years with our staple crops

William Carter Stubbs

SECOND SERIES,

No. 31.

BULLETIN

OF THE

Experiment Stations

OF LOUISIANA.

WM. C. STUBBS, PH. D., DIRECTOR.

DOMESTIC AND COMMERCIAL FERTILIZERS.

Results of Five Years With Our Staple Crops.

BY

WM. C. STUBBS, Ph. D., Director.

ISSUED BY THE STATE BUREAU OF AGRICULTURE.
A. V. CARTER, COMMISSIONER.

BATON ROUGE, LA.
PRINTED AT THE TRUTH BOOK AND JOB OFFICE.
1894.

LOUISIANA STATE UNIVERSITY AND A. & M. COLLEGE.

BUREAU OF AGRICULTURE.

GOV. MURPHY J. FOSTER, President.
WM. GARIG, Vice-President Board of Supervisors.
A. V. CARTER, Commissioner of Agriculture.

STATION STAFF.

WM. C. STUBBS, Ph. D., Director.
THOS. P. HUTCHINSON, Assistant Director, Audubon Park, New Orleans, La.
D. N. BARROW, B. S., Assistant Director, Baton Rouge, La.
J. G. LEE, B. S., Assistant Director, Calhoun, La.
WALTER MAXWELL, Ph. D., Chemist, Audubon Park, New Orleans, La.
J. L. BEESON, Ph. D., Chemist, Audubon Park, New Orleans, La.
R. L. BIVINS, B. S., Chemist, Audubon Park, New Orleans, La,
C. E. COATES, Ph. D., Chemist, Baton Rouge, La.
R. E. BLOUIN, M. S., Assistant Chemist, Baton Rouge, La.
M. BIRD, B. S., Chemist, Calhoun, La,
W. W. CLENDENIN, M. S., A. M., Geologist, Baton Rouge, La.
W. R. DODSON, A. M., Botanist, Baton Rouge, La.
R. T. BURWELL. M. E., Mechanical Engineer, Audubon Park, New Orleans, La.
H. A. MORGAN, B. S. A., Entomologist, Baton Rouge, La.
F. H. BURNETTE, Horticulturist, Baton Rouge, La.
S. B. STAPLES, B. S., D. V. S., Veterinarian, Baton Rouge, La.
J. T. GLYNN, Sugar Maker, Audubon Park, New Orleans, La.
E. G. CLARKE, Farm Manager, Audubon Park, La.
W. B. MERCIER, B. S., Farm Manager, Baton Rouge, La.
IVY WATSON, Farm Manager, Calhoun, La.
J. K. McHUGH, Secretary and Stenographer, Audubon Park, New Orleans, La.
H. SKOLFIELD, Treasurer, Baton Rouge, La.

The Bulletins and Reports will be sent free of charge to all farmers, by applying to Commissioner of Agriculture, Baton Rouge, La.

SUGAR EXPERIMENT STATION,
Audubon Park, New Orleans, La.

Col. A. V. Carter, Commissioner of Agriculture, Baton Rouge, La.:

DEAR SIR—The chemical amelioration of our soils is a question of paramount importance to every farmer in Louisiana. For five years the Stations of this State have been patiently studying the chemical wants of our soils and crops and have embodied the annual results in the bulletins already published. These results have been tabulated at great cost of labor, and this bulletin contains the deductions drawn from the published work of five years. Introductory to these deductions will be found a discussion of the forms of fertilizers used, together with a brief recital of the latest investigations relative to the care and preservation of stable manure. This bulletin is devoid of lengthy tables which are annoying to the average farmer and planter. I trust it may be read with interest and profit to all.

I respectfully ask that it be published as Bulletin No. 31.

Respectfully submitted,

WM. C. STUBBS,

Director.

DOMESTIC AND COMMERCIAL FERTILIZERS.

How best to renovate our worn soils and how to increase our annual crops by the proper selection and use of fertilizers are questions of paramount importance to every tiller of the soil in Louisiana. A discussion of these questions involves a review of all of our fertilizing resources and a proper selection and use of those materials which will accomplish our purposes at the least cost and without waste. Of the elements which go to make up the plant organisms all are usually supplied in great abundance by the soil, air and water, save three, viz: Nitrogen, Phosphoric acid and Potash. Everything which contains one or more of these ingredients is esteemed of value as a fertilizer and should be carefully husbanded and applied to the soil. So great has become the demand for these ingredients that an immense army with millions of capital is scouring the world for raw materials containing them, and another army with equally as large a capital is manipulating them into available fertilizers for the planters, farmers, gardeners and fruit growers of the world. How shall they be manipulated? What forms and in what proportions shall these raw materials be compounded to suit the wants of our crops? It is well known that different plants require different quantities of these ingredients for their best development and have different powers of extracting them from the same soil. Hence the necessity of experimentation.

In experimenting three factors have to be considered: 1st, The *chemical* composition and *physical* properties of the *soil*. 2d, The requirements of the plant to be grown, and 3d, the peculiar fertilizer which will give to the latter the maximum yield when grown on the former.

Experiments have been conducted at all three Stations of

this State for the last five years with all of our leading crops. These experiments cover every available home made manure as well as every obtainable commercial form of the three ingredients named above. Before giving the results a discussion of the fertilizers used will be in order. Under the head of

NITROGENOUS MANURES

we have used "Stable and Farm Manures," "Composts" with and without cotton seed and with and without acid phosphate; "Cotton Seed" "Raw," "Crushed" and "Rolled," "Cotton Seed Meal," "Nitrate of Soda," "Sulphate of Ammonia," "Dried Blood," "Fish Scrap" and "Tankage."

PHOSPHATIC MANURES

have been used as "Dissolved Bone Black," "Acid Phosphate," "Precipitated Dissolved Bone," "Precipated Acid Phosphate" "Bone Meal," "Bone Ash," "Floats" and "Iron Slag."

POTASSIC MANURES

have been represented by "Kainite," "Muriate of Potash," Sulphate of Potash," Nitrate of Potash," Carbonate of Potash" and "Ashes of Cotton Seed Hulls."

The forms of Nitrogen used are generally known to the agricultural world. Nitrate of Soda is an imported product, the world's supply coming from Chili and Peru, where in an impure state it is found in large quantities. It is refined and sent in limited quantities to the markets of the world.

Sulphate of Ammonia is a by-product in the manufacture of the coal gas of cities. Dried Blood is the product of the slaughter houses. When evaporated slowly it is "Red." When rapidly dried by steam it is "Black" Blood. "Fish Scrap" is the residue left from fish after the oil has been extracted. It is ground to a powder and sold to dealers and farmers. "Tankage" is the refuse of the slaughter houses. When blood and meat predominates the content of nitrogen is large. When bone predominates phosphoric acid is large and nitrogen is proportion-tionately decreased.

The forms of Phosphoric Acid are also fairly well known to our planters and farmers. The soluble forms, "Dissolved Bone Black" and "Acid Phosphate," have been made respectively from "Bone Black," and the ground "rock phosphate" by treatment with sulphuric acid. These treated with lime until the immediate effect of the acid is destroyed gives us "Precipitated Dissolved Bone Black" and "Precipitated Acid Phosphate." The agricultural value of Bone Meal depends largely upon its degree of fineness. Floats are "rock phosphate" ground to a powder so impalpable that it will *float* in the air, hence its name. Iron Slag is a bye product in the manufacture of steel from iron containing phosphorous and contains much free lime.

All commercial forms of *Potash* are products of the German mines. Cotton Seed Hull Ashes were formerly obtained from under the boilers of the cotton seed oil works of the country, where the hulls furnished the fuel to run the mills. Recently, however, the demand for hulls for feeding purposes has so enhanced their value as to preclude their further economical use as fuel. Cotton Seed Hull Ashes may therefore be regarded as out of the future market.

STABLE OR FARM MANURE

should stand first in the catalogue of manures and highest in the estimation of every progressive rational farmer. In this country few farmers appreciate the high value of this manure and they neglect to properly care for and utilize it has already involved many thousands of dollars of loss of soil fertility. It is absolutely necessary to convince our farmers of its high value ere they can be instructed as to the proper use of it. Farm manure, if properly made, consists of the fæces of all our farm animals mixed with the litter of the stable. It is therefore a combination of vegetable and animal matters, and contains all the elements organic and mineral necessary for plant growth. It decomposes under the proper conditions very rapidly; the fæces furnishing the fessment by which the vegetable matter is transformed into available plant food. Its application ameliorates the physical conditions of soils by rendering them more porous and permit-

ting a fuller respiration of the roots of plants growing therein. It supplies humus, a much needed ingredient in all our Southern soils. Nitrification, so essential to every fertile soil, is promoted by its presence, and recent experiments have shown that soils made fertile with it require *less water* to make a given amount of *matter*.

While it is generally assumed that stable manure as such is unassimilable by plants, and before it can be utilized must be decomposed, this is true only in a general sense, since Petermann has shown that this manure, as found in soils, is capable of being dialized through membranes and is therefore assimilable by some plants. Deherain has found in the stead of manure a carbonaceous substance easily decomposable, which he has called "vasculose," and this substance restores the carbonaceous principles of the soil exhausted by growing certain plants. Many French investigators believe that a fermentation which will give the largest amount of black mattter, "matiere noir," even with a small loss of nitrogen, is therefore the most desirable. While this view is not universally adopted, it is conceded by all that stable manure can restore both the nitrogenous and mineral matters removed by the plants.

Stable or Farm Yard manures vary greatly and depend for their composition 1st, the kind of animal; 2d, the quality of the food, and 3d, the kind and quantity of litter used for bedding. Therefore no fixed analysis of farm yard manure can be given. However, an approximate idea of the composition may be obtained by taking the analyses of the average manures from horses, cows, sheep and hogs, and the litter with which they are combined. It should be remarked that the liquid excrements are far richer than the solid in nitrogen and potash. Without giving the details, it will be sufficient for our purpose here to say that a horse will discharge in one year manure containing about 115 pounds nitrogen, 70 pounds phosphoric acid and 45 pounds potash. A cow in one year will void 170 pounds nitrogen, 26 pounds phosphoric acid and 107 pounds potash. A sheep 9 pounds nitrogen, 6 pounds phosphoric acid and 14 pounds potash, and a pig 12

pounds nitrogen, 9 pounds phosphoric acid and 10 pounds potash.

The tariff of prices regulating the relative values of commercial fertilizers sold in this State gives to nitrogen 19 cents a pound, 7½ cents per pound to phosphoric acid, and 5 cents per pound for potash. Applying these prices, the value of the droppings would be from a horse about $30, a cow $39, a sheep $2.85, and a pig $3.35. To a farmer owning three horses, five head of cattle, ten sheep and ten hogs, the money value of their droppings would be approximately $350 per annum. It can be seen then the economic necessity of carefully husbanding the manure from our farm animals in order to keep up the fertility of our soils.

The above constitutes the composition of the manure from farm animals. For the proper preservation and care of this manure it should be mixed with some substance that will act as an absorbent of the liquid portion and prevent its waste.

This is usually accomplished by the addition of litter to our stables, which serves the double purpose of a bed for the animal and an absorbent for the manure. What substance will best subserve such a purpose, is of the highest importance in our domestic economy. It is essential for the best results that the litter shalf have a high coeficient for the absorption of both water and ammonia, and at the same time present a comfortable bed for the animal. Unfortunately no one substance available to our farmers, will meet all of these requirements. Peat, dried and powdered, has the highest absorptive power of both water and ammonia, and should be used in all States where in can be obtained, but it is accessible to but very few of our farmers. The straws from oats, rice and various grasses, and the leaves of the pine, oak and other trees are usually used. These make comfortable beds and are excellent absorbents of moisture, but very low in their absorptive power of ammonia. Whenever possible a combination of straw and peat should be used. Especially are straws and leaves desirable if we concur in the value of black matter to our soils. Whenever the manures are left under the feet of the animals peat or a rich mold should always be used,

since it has been shown that the chief loss in such treatment of manure is in the escape of ammonia, which these substances arrest, a loss verying from one-quarter to one-half of the total nitrogen in the manure. It may here be remarked that peat and mold have far superior absorptive powers over plaster, kainite, acid phosphate, etc.

HOW SHALL MANURE BE TREATED?

It is usual to treat manure in one of three ways: 1st, To haul it out daily and apply at once to the soil, 2d, To let it remain under the animals and remove only when the crop is to be planted. 3d, To remove daily and compost either alone or with commercial fertilizers with or without shelter.

Which one of these practices should be followed depends 1st, upon character of soil; 2d, upon convenience of farmer, and 3d, to some degree upon the crop to be grown.

If the soil be a strong clay and disposed to pack, it is best to use the manure in its fresh condition, and therefore it may be hauled out daily and spread at once on the soil. Besides the chemical additions of nutrient elements of plant food, it will produce desirable physical changes in the soil itself, rendering it porous, facilitating aeration and nitrification.

It may be mentioned here that strong soils are frequently without immediate results from the application of manures, due partly to the fact that in their defective physical condition, they liberate annually as much plant food as the plant can assimilate under the prevailing conditions of drainage and rainfall. In our sugar belt commercial fertilizers are frequently without immediate results, due to defective drainage and to the further fact that these soils, well tilled, will produce the largest crops which the rainfall will permit. Hence drainage and irrigation are both needed for maximum results with the use of fertilizers on these soils. If the soil be light manures will nearly always produce their full effect provided the quantity used be not excessive. It is therefore best on such soils to use fermented manures. It is therefore advisable to select from the last two practices, which one will depend largely upon the time of farmer and price of

labor. When the farmer is pushed for time and labor high it is the part of wisdom to let it remain under the animals till needed in the field. Here slight fermentation takes place, with a liberation of ammonia, which must be assisted by the occasional application of peat or mold. There is moisture enough furnished by the urine to keep up the fermentation.

If the farmer has time, and his lands are of a sandy character, the COMPOST will always prove remunerative. Two kinds of composting are common in this State. 1st, Composting the manure alone, and 2d, with cotton seed and acid phosphate. The latter is always preferred if the seed and phosphate are obtainable.

The changes which take place in a simple compost have been closely studied and explained. In the upper part of a large heap the retained air contains nitrogen and carbonic acid, the latter coming from action of oxygen of the air on the organic matter in the manure. As a descent is made this nitrogen disappears and marsh gas accompanies the carbonic acid. In the upper part *ærobic* fermentation goes on, which is simply a combustion of the organic matter by the action of the air, which elevates the temperature to 112° F. to 150° F. in this part of the heap.

In descending the *ærobic* fermentation is displaced by the *anærobic.* Here the oxygen of the air is absent, and accordingly the temperature is only 80° F. to 100° F. Near the middle of the heap, if properly constructed, will be formed numerous stalactites of black matter, coming from the leachings of the manure and formed at a point where the manuer is saturated with liquid. This liquid may be urine alone or mixed with water. It percolates through the mass and by dissolving the ammonia and othes gases diminish the pressure within the pile, which draws in more air and thus keeps up the continued combustion with elevation of temperature. Therefore the manure leachings are frequently returned to the heap to revive or to increase the too slow fermentation.

The cellulose of the manure is converted into mareh gas and carbonic acid by the action of a ferment coming from the intes-

nes of the animal. These bacteria are found in the intestines of all herbivorous animals and are accompanied there by these same gases. Therefore the fermentation of farm manure may be considered as the natural digestion of the animal, prolonged after ejection.

The stracos found in the manure consists of cellulose, legnine, dextrin, sugars, gums, etc. In the upper path of the heap the more easily reducible substances, such as sugars, dextrin, gums, etc., are consumed by the oxygen of the air and converted into carbonic acid and water. Below this, the more resistant substances, such as cellulose, etc., are converted by the ferment without air, into marsh gas and carbonic acid. Tha vasculose is only partially destroyed, the greater part going into solution of the alkaline leachings. The ash is unaffected and remains constant during the fermentation.

The nitrogen is furnished by the liquid and solid portions of the manure as well as by the litter. Exactly what changes the nitrogenous substances undergo in a compost heap is not clearly known. The urea is converted into carbonate of ammonia. Whether this remains or is converted into albuminoids or other nitrogenous organic compounds, attendant with aloss of free nitrogen, are questions difficult to decide, on account of the complex reactions produced by the varying conditions under which different investigations have necessarily acted. The carbonate of ammonia formed from the urea is very volatile, as is evidenced by the pungent odor escaping from neglected stables, and if not arrested and fixed well form the chief loss in a covered manure heap. This form of ammonia is very soluble in water and if this heap be kept moist the loss will be very small. It is also largely absorbed by peat or rich garden mold, and hence the practice of the addition of these substances to our stables. The addition of either plaster, kainite, copperas or acid phosphate to the manure is sometimes made to prevent this loss of nitrogen. This practice, recommended by many, is opposed by a few, on the ground that either of these salts checks the natural fermentation and prevents that complete decomposition which is necessary for the perfect assimila-

tion of the manure by the plant. However, in a compost heap, properly constitused and kept moist, the loss of ammonia a very small.

In a well constructed manure heap it is highly desirable that it be kept moist, but not sufficiently wet to *leach*. It is therefore best to make them under shelter and add to them the needed water, than to make them "out of doors" and leave the rainfall to furnish the necessary water. Frequently heavy rainfalls will wash out of exposed manure heaps a considerable stream of black leachings. This should never occur, since they represent the cream of the manure, containing, besides the dissolved organic matter, much of nitrogen, phosphoric acid and potash. Sulphide of ammonia, coming from the reduction of the sulphates in the manure, gives the disagreeable oder to these leachings.

Farm manure is a perfect manure, since it contains all the elements of plant growth, but these elements are not arranged in proper proportions to suit the wants of many plants, hence it is not a *complete manure* in itself. To render it so additions of phosphates and potash salts are frequently made. These additions are made in quantities to suit the crop to be grown and the soil to which it is to be appllied, and are added to the manure before or at the time of application, or separately applied to the soil. In the cotton country a compost of stable manure, cotton seed, acid phosphate and kainite (when the soil requires it) is frequently used with excellent results. It may be prepared during the leisure moments of farm life (if such ever occur). It should be prepared under shelter and near a good supply of water. The following is the usual method :

DIRECTIONS FOR MAKING COMPOST.

Take an equal part of stable manure (say ten or twenty bushels) and spread it out in a level place, under shelter, to depth of three inches. Sprinkle over it 100 pounds acid phosphate. Next spread over this ten (or twenty) bushels of cotton seed, made *thoroughly wet*. Then another sprinkle of 100 pounds of acid phosphate. Continue this rotation till the quantities are exhausted and then cover with rich earth from the fence corners

five inches deep. Permit it to remain until ready for use (four to six weeks will do) and cut vertically down with a mattock.

Mix well and apply 300 to 1000 pounds per acre in the drill at the time of planting. Be careful to wet the cotton seed thoroughly and buy only a first-class acid phosphate.

In using acid phosphate and kainite due regard must be had for the demands of the crop under which it is to be used. Corn demands larger amounts of nitrogen than cotton, and cane larger than corn. Cotton responds best to large doses of phosphates, while tobacco revels in an excess of potash with nitrogen.

For corn 200 bushels stable manure, 200 bushels cotton seed and one ton of acid phosphate and 1000 pounds kainite (when needed) are about the right proportions for composting. For cotton the stable manure and cotton seed can be reduced one-half, the other ingredients remaining the same. For cane both stable manure and cotton seed can be increased, the increment depending largely upon natural fertility of the soil.

LEGUMINOUS CROPS.

No system is complete without at least one crop of legumes in the circle. This class of plants have the power of appropriating the nitrogen from the air, through the tubercles which grow upon their roots. These tubercles are filled with micro organisms which, while they draw most of their support from their host, the plant, they obtain their nitrogen from the air. Being of an ephemeral existence and multiplying rapidly, they are continuously absorbed by the plant and used for its development. Of these legumes we are familiar with Red, White, Crimson and Alsike clovers, Alfalfa, Mililotus, Vetches, etc. Two species of these plants are pre-eminent for their power of improving soils and are adapted to our Southern soils and climate. The sugar planters have for years demonstrated the value of our "cow pea" or "corn field pea" and the hill farmer of North Louisiana is wonderfully pleased with his new acquaintance, the "Spanish goober" or peanut. These two plants, if properly utilized, afford us a ready means of renovating our soils. They

will furnish the most expensive ingredient of fertilizer, nitrogen, at the lowest cost, besides frequently ameliorating the physical condition of our soils. The estimated fertilizing value of an acre of "clay" pea vines, after carefully harvesting, weighing and analyzing both vines and roots upon the grounds of the Sugar Experiment Station, was equal to the combined effect of 920 pounds cotton seed meal and 770 pounds kainite (see Vol. III, Bulletin No. 14, pages 71 *et seq.*) The vines and roots from this acre gave by analysis 64.95 pounds nitrogen, 20.39 pounds phosphoric acid, 110.56 pounds potash and 42.6 pounds lime. All but the Nitrogen was drawn from the soil. The greater part of the nitrogen doubtless came from the air.

The similar value of an acre of "goobers" has not yet been determined, but it is known to be large. Whenever sufficient stock is kept to consume the hay, and the manure therefrom is carefully saved and returned to the land, neither "cow peas" nor "goobers" should be turned under "green," but harvested and fed, since they make excellent hay when rightly cured, and the fertilizing ingredients are but slightly diminished in their passage through the animal's stomach. The plants are thus made to do double duty of feeding the animal and fertilizing the soil. True economic science would always direct the conversion of these crops into hay and fed to animals and the manure therefrom scrupulously returned to the soil. When an insufficient number of animals are kept to consume the hay, or when the manure from the stables is thrown away, then the true theory would be to turn these crops under as "green manure."

"Of "goobers" the Spanish variety is "par excellence" the best, being easily gathered in sandy soils with all the nuts adherent to the vine. Of cow peas, we have a great variety. That kind should be selected for hay or for renovating the soil which will give the largest amount of vines and occupy the ground until frost. The "clay" variety has heretofore been the favorite of the sugar planter, but the "Unknown," a comparatively new variety, promises to succeed it. The latter gives more and longer vines, grows well into the fall, and bears a late but large crop of pods. Comparative field tests, with chemical analyses,

have been made of a large number of varieties and results will be embodied in a future Bulletin.

THE SOILS OF THE THREE STATIONS.

At Audubon Park the soil is alluvial, none of it very sandy, and but little of it very stiff. It is an excellent quality of "mixed" soil. The following analyses of the lightest and stiffest soils on the Station will give an accurate idea of its composition:

ANALYSES OF SOILS OF AUDUBON PARK SUGAR EXPERIMENT STATION, NEW ORLEANS, LA.

	Light Soil.	Dark Soil.
Insoluble matter	70.10	62.05
Potash	.44	.75
Soda	.12	.18
Lime	.79	.91
Magnesium	.81	1.36
Ferric and Aluminic oxides	11.28	13.44
Phosphoric acid	.16	.15
Sulphuric acid	.02	.03
Organic matter	3.16	6.65
Water	13.23	14.46
Nitrogen	.112	.085

These are excellent soils, their chemical composition insuring heavy yields, provided drainage and rainfall would conspire to produce them. These soils, like all others in the sugar belt, require *thorough* drainage. It may be asserted that few years furnish water enough during the growing season for developing the maximum crops these soils, unaided by fertilizers, can produce if properly drained. Hence frequently commercial fertilizers fail to give increased production, and they are condemned as worthless, when really the seasons have not permitted the growing crops to appropriate the available fertility of the unaided soil. Hence field experiments are very unsatisfactory unless conducted through a series of years.

STATE EXPERIMENT STATION, BATON ROUGE, LA.

Here the soil is a brown loam, belonging, geologically, to the Bluff Formation. The fields are "rolling" and penetrated by a bayou which insinuates through the entire tract. When well drained it is excellent upland, but unfortunately general

drainage is harder to obtain here than on the alluvial belt, since there is no one line of slope along which the ditches can be cut. Frequently the level land on the highest places is the hardest to drain, and hence great difficulty is experienced in obtaining duplicate plats with similar physical features and properties for experimental purposes. This brown loam soil is underlaid at varying depths by a white chalky looking clay. Frequently considerable areas of this white clay are exposed by the denudation of the overlying brown loam. This clay is intractable and impervious to water.

The following analyses will show the comparison of the soils of this Station:

ANALYSES OF SOILS AND SUB-SOILS OF STATE EXPERIMENT STATION, BATON ROUGE, LA.

No. 1 a. Typical bluff soil.
No. 1 b. Sub-soil corresponding to the same.
No. 2 a. White soil.
No. 2 b. Sub-soil underlying white soil.

	1 a.	1 b.	2 a.	2 b.
Sand and insoluble matter	90.650	89.79	87.72	83.00
Soluble Silica	.133	.043	.0784	.097
Phosphoric acid	.064	.128	.112	.106
Sulphuric acid	.036	.025	.021	.016
Ferric oxide and Alumina	4.225	6.510	6.670	8.880
Lime	.170	.163	.060	.120
Magnesia	.114	.160	.021	.085
Potash	.100	.164	.120	.180
Soda	.078	.054	.076	.123
Organic and volatile matter	3.150	2.741	2.820	4.210
Moisture	1.540	.874	2.380	3.320

These soils show goodly percentages of lime and potash, but their content of phosphoric acid is small.

NORTH LOUISIANA EXPERIMENT STATION, CALHOUN, LA.,

is situated in the short leaf pine hills of North Louisiana. The soil varies from yellow sandy clays to pure sands, They are naturally very poor, but susceptible of rapid improvement and responsive to the smallest application of manures. In fact, no

where can soils be found more satisfactory to the experimenter with fertilizers than those of this Station. Their physical qualities are good and chemical analyses reveal their low fertility.

The following is the analyses of the soils of this Station :

ANALYSES OF SOILS OF NORTH LOUISIANA EXPERIMENT STATION, CALHOUN, LA.

	From Front Field of Station.	From Rear Field of Station,
Insoluble matter	97.010	95.510
Potash	.023	.029
Soda	.029	.058
Lime	.085	.145
Magnesia	.018	.074
Ferric oxide	.336	.529
Alumnia	.762	.829
Phosphoric acid	.037	.048
Sulphuric acid	Trace.	Trace.
Organic matter	1.575	2.225
Water	......	......
Soluble Silica	.120	.090
Nitrogen	.025	.037

These soils reveal their poverty by above analyses.

PHYSICAL PROPERTIES.

The physical properties of the soils of these Stations have not yet been thoroughly studied. Investigations are now going on looking to a complete study of their relations to air, water and applied fertilizers, etc.

MANURIAL NEEDS OF THESE SOILS.

Do these soils need Nitrogen, or Phosphoric Acid or Potash to grow our staple crops successfully ?

If so, in what forms shall they be used ?

What quantities of each will give the largest profit ?

These questions have been propounded for five years upon each one of the three Stations.

The forms of each ingredient used has already been described. To test the full effect of any one ingredient, all the rest must be supplied in excess. Therefore our experiments have been arranged to include plats with no manure to show the natural fertility of the soil; plats with only the single ingredient experimented with; plats with all the other ingredients, save one experimented with, applied in excess, and plats with all the ingredients applied, using the ingredient experimented with in one and two rations. 24 Pounds of Nitrogen per acre has been styled one ration; 48 pounds two rations; 36 and 72 pounds have similarly been denominated one and two rations of Phosphoric Acid; 25 and 50 pounds one and two rations of Potash. A mixture of Potash, (50 lbs.) and Phosphoric Acid (72 lbs.) is called "mixed minerals. A mixture of Nitrogen (48 lbs.) and Potash (50 lbs.) is called Basal mixture, while Nitrogen (48 lbs.) and Phosphoric Acid (72 lbs.) is called Nitrogen Phosphate. Results have been given for each year in the bulletins from the separate Stations. In this only the aggregate of five years will be presented.

NITROGEN EXPERIMENTS.

1st. Do these soils need Nitrogen to grow our staple crops?

2d. If so, in what form shall it be supplied?

3d. In what quantity?

The crops tested are sugar cane, corn, oats and cotton at Audubon Park. Cotton, corn, sugar cane and potatoes at Baton Rouge, and cotton, corn, sugar cane, tobacco and potatoes at Calhoun.

The forms of Nitrogen used were cotton seed, cotton seed meal, dried blood, fish scrap, tankage, nitrate of soda and sulphate of ammonia at all three Stations. At Calhoun crushed cotton seed, rolled cotton seed and compost of cotton seed, stable manure and acid phosphate were used in addition to the above on corn and cotton.

The quantities used have been 24 pounds (one ration) and 48 pounds (two rations) per acre.

The first question has been answered affirmatively in very

positive terms for every crop at Calhoun, the use of one ration of Nitrogen alone frequently doubling the crop. When combined with mixed minerals, the crop has often been increased three fold.

At Audubon Park the reply has been in the affirmative, very positive in favorable seasons, and fully in unfavorable ones.

At Baton Rouge this reply has been an affirmative more or less dependent upon the phosphoric acid present.

It may therefore be asserted that the *crying want* of the Calhoun soils is Nitrogen. That the soils of Audubon Park under favorable seasons will appropriate one to two rations of Nitrogen (more has been demonstrated to be a loss) with profit.

Baton Rouge soils are responsive to Nitrogen only when properly combined with phosphoric acid.

The second question has not been so positively answered anywhere. At Audubon Park through four years of careful experimentation on sugar cane, cotton seed meal slightly leads all other forms (due doubtless to small amount of phosphoric acid present) followed closely by sulphate of ammonia, fish scrap and nitrate of soda. These in turn are followed by tankage and dried blood. The average yield of corn per acre in tons, when treated with these forms, used alone and combined in one and two rations with mixed minerals, have been as follows: Cotton seed meal 33.10, sulphate of ammonia 32.55, fish scrap 31.68, nitrate soda 30.80, tankage 29.98, dried blood 29 23. On other crops, particularly on black, stiff land, sulphate of ammonia has given slightly better results.

At Baton Rouge Sulphate of Ammonia has also lead, followed closely, however, by the other forms. No composts have ever been used at either of these Stations.

At Calhoun the compost of cotton seed, stable manure and phosphate have led all other forms under cotton, and the order in which they have stood for five years, assuming the yield of the natural soil at 100, is as follows: Compost 302 per cent., crushed cotton seed 268 per cent., nitrate of soda 258 per cent., cotton seed meal 244 per cent., fish scrap 204 per cent., tankage

178 per cent., sulphate of ammonia 166 per cent., rolled cotton seed 163 per cent., and dried blood 129 per cent.

On corn the following in similar per centages were obtained: Nitrate soda 231 per cent., fish scrap 231 per cent., compost 229 per cent., rolled cotton seed 223 per cent., sulphate ammonia 183 per cent., crushed cotton seed 182 per cent., cotton seed meal 174 per cent., dried blood 170 per cent and green cotton seed 165 per cent.

The results given above were obtained by the application of the same manures to the same plats through five years, and much of the differences may be ascribed doubtless to the inequalities of soil. It may be said, therefore, that there is but little preference in any of the forms of Nitrogen given above. It is worthy of record here that of the two mineral forms of Nitrogen the nitrate of soda is to be preferred upon light sandy soils, and sulphate of ammonia upon stiff clay lands. Attention should also be called to the danger of loss of nitrogen in the careless rolling of cotton seed. The quantity of Nitrogen to be used per acre will depend largely upon 1st, character of soil, and 2d, season. Poor land cannot appropriate heavy doses of Nitrogen nor will fairly fertile soils in bad tilth. Hence the good judgment of the farmer must decide the quantity. At Calhoun, upon thin soils, one ration (24 lbs.) of Nitrogen is nearly the maximum quantity which crops can now appropriate. With improvement these soils may digest and render available increased quantities. At Baton Rouge, with favorable seasons, two rations (48 pounds) of Nitrogen may be assimilated by the crops with profit, though on account of almost annual droughts, it is unwise to apply as a rule larger quantities than one ration (24 pounds). Experiments at both of these Stations have determined the above. At Audubon Park, two rations (48 pounds) can easily be assimilated by sugar cane in a fair season, provided the soil be well drained and cultivated, *i. e.*, in good tilth. Experiments have shown that three rations are excessive and always produce a waste. On cotton, corn and oats lesser quantities of Nitrogen will suffice. Irish potatoes, cabbage, etc., may easily dispose of with profit 72 pounds (3 rations) of Nitrogen per acre.

In determining the quantity of Nitrogen required by a crop a due regard must be given to its botanical relations and its peculiar appetite. Cereals of all kinds will require more Nitrogen than cotton or cow peas.

PHOSPHORIC ACID EXPERIMENTS.

1st. Do these soils require Phosphates to grow our staple crops?

2d. If so, in what form shall they be used?

3d. And in what quantities?

In many of our experiments to test the above questions we have used cotton seed meal to supply our Nitrogen. This substance contains besides its 7 per cent. of Nitrogen, 3 per cent. of Phosphoric Acid and 2 per cent. of Potash. Therefore, where only small quantities of Phosphoric Acid are needed, it may be supplied through this form of Nitrogen. It is believed that the faint responses sometimes obtained are due to the use of cotton seed meal as a source of Nitrogen; this when used to supply 24 pounds of Nitrogen per acre furnishes at same time 10½ pounds Phosphoric Acid, or near as much as is usually contained in 100 pounds Acid Phosphate. Lately we have used only the pure forms of Nitrogen in solving the above questions, At Calhoun and Audubon Park it has been found that phosphates used alone have given only small increments to our crops, but when properly combined with Nitrogen their effects have been more apparent. Cotton requires proportionately more phosphates than corn and corn more than tobacco or sugar cane.

At Baton Rouge the effects of Phosphates are everywhere visible to the eye, and every fertilizer should contain goodly proportions of this ingredient, which is designed for this soil. It may therefore be asserted that the soils of Audubon Park and Calhoun require only small doses of phosphates, mixed with strongly nitrogenous fertilizers to give remunerative returns, while the soils of Baton Rouge can consume goodly quantities with increased crop products.

2d Question. This is answered in unmistakable terms, the soluble forms are the most profitable on every Station, followed

by the slag meal among the insoluble phosphate. Bone meal, even with its 3 per cent. or more of Nitrogen, has not on any of these soils given paying results.

The third question is answered in quite as positive terms as the one above. Neither at Calhoun nor Audubon Park have excessive quantities been beneficial. At the former perhaps 24 pounds soluble phosphoric acid per acre is an abundance for any crop. While one ration (36 lbs.) has been found to be ample for the cane crop at the latter Station at Baton Rouge. Upon the best character of soils and in favorable seasons 50 pounds or more to the acre of this ingredient might be profitably applied to certain crops.

Since this crop does not leach out like Nitrogen, it is not a total loss to apply it in excessive quantities.

POTASSIC MANURES.

1st. Do these soils need Potash for the growth of our staple crops?

2d. If so, in what form shall it be given?

3d. In what quantities per acre?

In most of our experiments conducted to test the above questions, cotton seed meal has been used to supply the Nitrogen. This substance contains, as stated elsewhere, 2 per cent. Potash. Except in our experiments with cane, where sulphate of ammonia was used to furnish the Nitrogen, all the others were conducted with cotton seed meal, and therefore results *may* mean that the amount of Potash contained in the meal is sufficient for most crops. No crop at any one of the three Stations has been benefited by the application of potassic salts. This seems almost incredible when the sandy nature of the soil at Calhoun is considered, but crucial tests made upon such potash loving plants sas tobacco, Irish potatoes and corn have failed to demonstrate any advantage from the use of potash. At Calhoun, under cotton for five years, the average aggregate yield has been for unfertilized plats, 600 pounds; for plats receiving potassic manures only 535 pounds; plats receiving cotton seed meal and acid phosphates, 996 pounds; while plats receiving the last with one

ration (25 lbs.) and two rations (50 lbs.) of potash in all its forms give respectively 958 pounds and 982 pounds.

Similar yields were obtained for corn. The average of "No Manure" was 13.45 bushels; for potassic manures alone 12.38 bushels; for cotton seed meal and acid phosphate 21.30 bushels; for same with one and two rations of potash added 20.90 and 20.80 bushels. At Baton Rouge similar results have been obtained. At Audubon Park, upon the same cane, on the same plats for four years as high as 50 pounds potash in all its forms have been annually applied without any appreciable increase either in tonnage or sugar content. An examination of the tobacco bulletins will show negative results from its use under this plant.

It may therefore be asserted that at present these soils do not need potash to grow any crop, but the supply of this ingredient in the hill soils of North Louisiana is so small that it may be needed and needed badly in a short while. Therefore it may not be a total loss to use fertilizers containing small percentages of this ingredient upon the sandy lands of this section.

No form of Potash producing results, it is of course impossible to say which will be best when it is needed. Under tobacco, Irish potatoes and sugar beets the Sulphate of Potash is preferred to any other form for physiological effects. With all other crops the other forms are considered effective.

Soils in their natural condition furnish enough of each one of the fertilizing ingredients to made a fair average crop, but when they are improved by a judicious rotation and fertilization, the increased products may require more potash than the soil can supply, then it may be necessary to supply potash. This may happen at Calhoun and Baton Rouge, but is hardly possible at Audubon Park.

APPLICATION OF FERTILIZERS.

Having determined the ingredients required by our soils, and having prepared mixtures to suit these requirements, the next question is, *How shall they be applied? Shall they be applied broadcast or in the drill? Shall they be applied before planting, at*

planting, or after growth begins? In their use shall we make one, two or three applications? At what depth shall they be placed, both in the drill and broadcast?

With such crops as oats, wheat, grasses, clovers, etc., fertilizers must be applied broadcast, unless they are planted with a drill with fertilizer attachment. It is possible under such circumstances to apply in the drill, but this would be a close approximation to broadcast, on account of closeness of the drills. But where crops are cultivated in rows from two to eight feet wide, fertilization is practicable both broadcast and in the drill. Where the soil is open and porous and root development can occur without hindrance, then broadcasting may be done, with chances that the fibrous roots, permeating easily in every direction, may catch most of the applied fertilizers, but in very stiff, compact soils such extensive root development is impossible and therefore much of the broadcast fertilizer will not be accessible to the roots of the growing crop. As a rule then it may be asserted that broadcasting is permissable upon hoed crops in light soils, but wasteful in stiff, heavy soils. But is it advisable where the prime object is to recover in the present crop the fertilizer applied? To test this question a series of experiments were made upon the light soils of Calhoun, by duplicating the same amount and kind of fertilizers upon several crops, broadcast and in the drill, and their universal verdict was in favor of the drill. Of course there is a limit to the amount that can be safely put in the drill, and this limit depends largely upon the tilth of the soil and the rainfall. Poor, thin soils can rarely stand in the drill more than 300 to 500 pounds of a concentrated fertilizer, nor can they appropriate more even if put on broadcast. A soil must be fed according to its ability to digest, and thin soils are "sick patients" that must be gradually strengthened before they can digest large quantities of fertilizers. Upon stiff clayey or even fertile loamy soils, application in the drill either under the plant before planting or along either side during cultivation seems preferable to broadcast.

The time of application as well as the *number of applications* must depend largely upon 1st, the character of the soil. 2d,

Root development. 3d, The quality of the fertilizer, and 4th, seasons.

If the soil be very loamy or clayey and retains fertilizers well, perhaps little or no loss will occur by putting all the manure under the plant at the time of planting. But if the soil be sandy and inclined to "leach," fertilizers, particularly Nitrogen compounds, should never be applied *all at once* under *fibrous rooted* plants. Mineral fertilizers may be thus applied, since they leach but little, and even complete fertilizers may be thus used under quickly growing tap rooted plants. But fibrous rooted plants, like corn, sugar cane, sorghum, etc., will usually respond best on such soils to two or more applications. Nitrogenous manures are very fugacious and have to be handled with care to avoid loss, while phosphatic and potassic manures become fixed soon after contact with the soil. Tap root plants, like cotton and cow peas, have the capacity of drawing up their food from greater depths than the fibrous rooted, like corn, and therefore may arrest and appropriate food beyond the reach of the latter. Seasons, too, modify results. In seasons of heavy rainfall the loss from leaching is enhanced, while it is minimized by a prolonged drought.

Experiments at Calhoun, extending over five years, emphasize the above remarks. With cotton, using all forms of Nitrogen, with and without mixed minerals, in one, two and three applications, *i. e.*, all at time of planting; one half at time of planting and the rest at second cultivation; or one-third at time of planting, one-third at second working and one-third at lay-by, the aggregate results are as follows: One application, 1084 pounds seed cotton; two applications, 1015 pounds; three applications, 1014 pounds. Only seven times out of sixty experiments extending over five years have two or more applications given increased yields, and five out of these have been with "mixed Nitrogens," *i. e.*, a mixture of Nitrate of Soda, Sulphate of Ammonia and Cotton Seed Meal. The results of these experiments strongly justify one application at time of planting under cotton. Different results have been obtained with corn and sugar cane at this Station, from similar experiments. With corn two

applications have given an annual increased yield of 1.38 bushels, and three applications 3.56 bushels over one application. Three applications have yielded 2.18 bushels over two applications. These experiments, the duplicate of those described under cotton, extending also over five years, strongly suggest the practice of making at least three applications of fertilizers to such plants as corn, cane, etc., upon these soils. At Baton Rouge little or no loss has occurred from one application at time of planting, and therefore the question has not been investigated as thoroughly as at Calhoun.

At Audubon Park the propriety of putting out fertilizers under the cane at planting in the fall or spring, or of applying on either side of cane at time of returning the soil to the young cane, has been thoroughly investigated with results favorable to either. Experiments have been made similar to those discussed above with one, two and three applications, with as yet no positive evidence against the prevailing custom of one application. These experiments are not yet completed, and final results may alter our present opinion.

At what depth shall fertilizers be applied to give maximum results? Experiments covering this entire question have been systematically made for five years. Complete fertilizers have been applied at all depths from the surface to eight inches. Then omitting the Nitrogen, the mineral ingredients have been applied at different depths and Nitrogen on the surface. Finally mixed minerals applied at one depth and Nitrogen at another. The last two are based upon the well known properties of the ingredients of fertilizers, already mentioned, in their behavior towards the soil. The consensus of results points unmistakably to a depth of two to three inches as producing the best results, and also shows the advantage of having all the ingredients combined at this depth.

ROTATION CF CROPS.

No system of farming is considered permanently profitable without a rotation of crops, and no rotation is complete without at least one renovating crop. Every civilized country is on the

lookout for a valuable leguminous crop that is adaptable to the rotation already established. The sugar planters of South Louisiana very generally practice a rotation of sugar cane, corn and cow peas. By turning under the last mentioned crop the fertility of their soils is maintained. But the cotton planter has no rotation. It is cotton, cotton, cotton, with occasionally small areas in corn. The latter is allowed to grow and mature without the presence of the cow pea, which the sugar planter has found to be such a valuable renovator of his soils. Under this exclusive cotton culture much of the lands of North and Middle and East Louisiana have become so depleted of their original fertility as to fail to give remunerative returns for the labor of cultivation. The question of paramount importance to every patriotic citizen of Louisiana is how to restore these worn and tired soils. It is of vital interest to the owners of these lands to know how to do this, and at the same time receive a fair remuneration for the labor and expense involved in its accomplishment. This the Stations have attempted to solve and a recital here of the results obtained through five years will, it is hoped, convince a few that the plan is a feasible one and worthy of trial. At Baton Rouge and Calhoun, nearly six year, ago, six acres were laid off in acre plats, and the system of rotation of crops, with and without fertilizers, began.

The crops selected were oats, cow peas, cotton, corn and cow peas, or five crops in three years. It would be more in accordance with science to follow a crop of cow peas with corn, but experience has proven that the Rust Proof oat (the only variety which can be successfully grown here) must be planted in October to insure a certain crop, and to plant it in this month it must follow a crop of corn, since the cotton crop could not be gathered by this time. Hence the order adopted. Three parallel plats of two acres each are used for the experiments. The front acre of each is fertilized with a fertilizer suitable to the crop occupying it, while the rear acre is left unfertilized. Otherwise the plats are treated alike. The rotation began with oats in Plat No 1 (front acre fertilized and the rear acre not). Plat No. 2 in corn and cow peas (front acre fertilized, rear acre not).

Results of Experiments

WITH

DIFFERENT KINDS OF FERTILIZERS

AT

AUDUBON PARK, NEW ORLEANS,

FOR 1892 AND 1893.

The following tables give the yields under stubble cane of the various forms of fertilizers described in this Bulletin :

PLAT III "a"—RESULTS OF EXPERIMENTS WITH POTASSIC FERTILIZERS, 1892, SECOND YEAR STUBBLE, HARVESTED NOV. 22.

No. of Experiment.	Fertilizers Per Acre.	Tons Per Acre.	Analyses of Juices.		
			Brix	Sucrose.	Glucose.
1	210 lbs. Kainite	21.70	15.3	11.7	1.87
2	Nitrogen Phosphate* / 210 lbs. Kainite	29.68	14.6	11.0	1.84
3	Nitrogen Phosphate / 420 lbs. Kainite	23.10	14.4	11.1	1.73
4	Nitrogen Phosphate	30.94	14.3	10.4	1.91
5	50 lbs. Sulphate Potash	21.91	15.2	11.8	1.93
6	Nitrogen Phosphate / 50 lbs. Sulphate Potash	23.59	14.5	10.1	2.14
7	Nitrogen Phosphate / 100 lbs. Sulphate Potash	24.71	14.2	9.7	2.09
8	No Manure	20.16	15.2	11.5	1.76
9	50 lbs. Muriate Potash	23.52	15.7	12.3	1.63
10	Nitrogen Phosphate / 50 lbs. Muriate Potash	23.94	15.4	12.0	1.66
11	Nitrogen Phosphate / 100 lbs. Muriate Potash	26.67	14.7	10.7	2.05
12	Nitrogen Phosphate	25.62	15.3	11.8	1.79
13	200 lbs. Cotton Seed Hull Ashes	28.84	14.7	11.4	1.63
14	Nitrogen Mixture† / 200 lbs. Cotton Seed Hull Ashes	22.38	15.5	12.2	1.61
15	Nitrogen Phosphate / 200 lbs. Cotton Seed Hull Ashes	27.80	14.9	11.6	1.71
16	Nitrogen Phosphate / 108 lbs. Nitrate Potash	27.30	15.5	12.0	1.85
17	Nitrogen Phosphate / 210 lbs. Nitrate Potash	28.91	15.6	11.8	1.62

*Nitrogen Phosphate—48 pounds Nitrogen and 72 pounds Soluble Phosphoric Acid.

†Nitrogen Mixture—48 pounds Nitrogen.

PLAT IV "a"—RESULTS OF PHOSPHORIC ACID EXPERIMENTS, SECOND YEAR STUBBLE, 1892, HARVESTED DECEMBER 12.

No. of Experiment.	Fertilizers Used Per Acre.	Tons Per Acre.	Analyses of Juices.		
			Brix.	Sucrose.	Glucose.
1	258 lbs. Dissolved Bone Black..................	28 05	14.9	11.0	1.87
2	258 lbs. Dissolved Bone Black and Basal Mixture*	30.01	14.5	10.1	2.19
3	516 lbs. Dissolved Bone Black and Basal Mixture	31.92	15.0	10.0	2.12
4	Basal Mixture..................................	28.77	14.8	10.5	2.12
5	258 lbs. Acid Pho·phate........................	26.14	15.2	10.9	2.18
6	258 lbs. Acid Phosphate and Basal Mixture......	27.40	15.3	10.4	2.14
7	516 lbs. Acid Phosphate and Basal Mixture......	31.25	15.1	10.3	2.23
8	No manure......................................	22.60	15.1	10.4	2.06
9	516 lbs. Bone Black............................	24.54	15.5	10.5	2.11
10	516 lbs. Bone Black and Basal Mixture.........	23.60	14.9	10.8	2.03
11	516 lbs. Slag Meal............................	26.30	15.1	11.3	1.97
12	516 lbs. Slag Meal and Basal Mixture..........	27.25	15.3	11.2	2.02
13	Basal Mixture.................................	27.84	15.4	11.2	2.09
14	516 lbs. Charleston Floats....................	24.43	15.5	11.6	2.03
15	516 lbs. Charleston Floats and Basal Mixture....	27.11	15.7	10.9	1.99
16	No Manure.....................................	23.54	15.5	11.5	1.87
17	516 lbs. Ground Bones.........................	27.74	15.6	11.3	1.89
18	516 lbs. Ground Bones and 100 lbs. Sulphate of Potash..............................	27.74	15.4	11.4	1.97
19	516 lbs. Ground Bones and Basal Mixture......	26.53	15.4	10.9	1.93

*Basal Mixture—230 pounds Sulphate of Ammonia and 100 pounds Sulphate of Potash.

PLAT V "a"—RESULTS OF EXPERIMENTS WITH NITROGENOUS FERTILIZERS, 1892, SECOND YEAR STUBBLE, HARVESTED DECEMBER 15, 1892.

No. of Experiment.	Fertilizers Used Per Acre.	Tons Per Acre.	Analyses of Juices.		
			Brix.	Sucrose.	Glucose.
1	350 lbs. Cotton Seed Meal	28.63	14.8	11.5	1.17
2	350 lbs. Cotton Seed Meal and Mixed Minerals*.	32.69	14.8	11.4	1.42
3	700 lbs. Cotton Seed Meal and Mixed Minerals	34.72	15.1	11.7	1.35
4	Mixed Minerals	34.23	14.1	10.8	1.52
5	200 lbs. Dried Blood	29.82	15.7	11.5	1.66
6	200 lbs. Dried Blood and Mixed Minerals	28.77	14.2	10.9	1.41
7	400 lbs. Dried Blood and Mixed Minerals	30.17	14.8	11.9	1.23
8	No Manure	26.14	14.4	12.0	1.19
9	115 lbs. Sulphate Ammonia	28.21	14.1	11.1	1.39
10	115 lbs. Sulphate Ammonia and Mixed Minerals.	35.21	14.2	11.4	1.34
11	230 lbs. Sulphate Ammonia and Mixed Minerals.	32.06	14.4	11.6	1.16
12	Mixed Minerals	31.64	14.8	12.1	1.13
13	160 lbs. Nitrate Soda	29.25	15.2	12.7	1.11
14	160 lbs. Nitrate Soda and Mixed Minerals	28.35	15.3	12.9	1.00
15	320 lbs. Nitrate Soda and Mixed Minerals	29.47	15.7	13.3	.91
16	No Manure	24.15	15.7	13.5	.88
17	400 lbs. Tankage	27.16	15.6	13.2	1.08
18	400 lbs. Tankage and Mixed Minerals	26.81	15.3	13.2	1.00
19	280 lbs. Fish Scrap	24.78	15.1	13.0	1.02
20	280 lbs. Fish Scrap and Mixed Minerais	28.14	14.8	12.8	1.12

*Mixed Minerals—180 pounds Acid Phosphate and 100 pounds Sulphate of Potash.

PLAT IV "a"—FIELD RESULTS—PHOSPHORIC ACID MANURES, 1893, THIRD YEAR STUBBLE, HARVESTED DECEMBER 16 AND 17.

No. of Experiment.	Fertilizers Used per Acre.	Tons per Acre.	Analyses of Juices.			
			Brix.	Total Solids.	Sucrose.	Glucose.
1	258 lbs. Dissolved Bone Black..........	13.09	14.1	13.6	10.4	1.79
2	258 lbs. Dissolved Bone Black and Basal Mixture*	19.60	13.0	12.4	8.9	2.10
3	516 lbs. Dissolved Bone Black and Basal Mixture	19.67	13.5	13.5	9.5	2.10
4	Basal Mixture	17.85	12.6	12.2	8.5	2.16
5	258 lbs. Acid Phosphate..................	15.05	13.5	13.3	9.6	2.19
6	258 lbs. Acid Phosphate and Basal Mixture	19.25	14.0	11.6	10.1	2.02
7	516 lbs Acid Phosphate and Basal Mixture	13.02	15.3	15.2	12.2	1.56
8	No Manure..........................	7.56	16.1	15.7	13.0	1.32
9	516 lbs. Bone Black......................	11.62	15.3	14.9	12.0	1.72
10	516 lbs. Bone Black and Basal Mixture...	12.18	16.1	15.3	12.8	1.39
11	516 lbs. Slag Meal	16.80	13.3	13.9	10.5	2.04
12	516 lbs Slag Meal and Basal Mixture.....	24.01	15.3	14.8	11.8	1.58
13	Basal Mixture..........................	19.11	16.1	15.7	13.0	1.52
14	516 lbs. Charleston Floats	21.21	15.4	14.4	12.1	1.37
15	516 lbs. Charleston Floats and Basal Mixture	19.95	15.5	14.9	12.3	1.53
16	No Manure..............................	18.69	15.8	15.2	12.7	1.41
17	516 lbs. Ground Bone....................	17.50	16.0	15.4	13.0	1.3[illegible]
18	516 lbs. Ground Bone and 100 lbs. Sulphate Potash.	15.96	15.6	14.7	12.5	1.42
19	516 lbs. Ground Bone and Basal Mixture..	16.66	16.1	15 6	13.2	1.30

* Basal Mixture—230 lbs. Sulphate Ammonia and 100 lbs. Sulphate Potash.

PLAT V "a"—FIELD RESULTS—NITROGENOUS MANURES, 1893, THIRD YEAR STUBBLE, HARVESTED NOVEMBER 15.

No. of Experiment	Fertilizers Used Per Acre.	Tons Per Acre.	Analyses of Juices.			
			Brix.	Total Solids.	Sucrose.	Glucose.
1	350 lbs. Cotton Seed Meal	17.82	15.8	15.5	12.5	1.38
2	350 lbs. Cotton Seed Meal and Mixed Minerals	27.60	15.4	15.4	11.9	1.46
3	700 lbs. Cotton Seed Meal and Mixed Minerals	23.87	15.3	......	12.7	1.25
4	Mixed Minerals	23.35	15.5	15.6	12.0	1.50
5	200 lbs. Dried Blood	19.60	15.0	......	11.5	1.61
6	200 lbs. Dried Blood and Mixed Minerals	20.41	15.0	14.9	11.2	1.84
7	400 lbs. Dried Blood and Mixed Minerals	17.94	15.4	15.1	11.7	1.75
8	No Manure	13.08	15.1	......	12.1	1.74
9	115 lbs. Sulphate Ammonia	18.31	15.0	14.7	11.5	1.76
10	115 lbs. Sulphate Ammonia and Mixed Minerals	24.73	15.4	15.0	12.1	1.73
11	230 lbs. Sulphate Ammonia and Mixed Minerals	26.64	15.1	15.0	11.8	1.67
12	Mixed Minerals	23.75	15.4	14.8	11.7	2.32
13	160 lbs. Nitrate of Soda	19.83	15.5	14.6	11.9	1.92
14	160 lbs. Nitrate Soda and Mixed Minerals	22.63	16.2	15.9	12.8	1.52
15	320 lbs. Nitrate Soda and Mixed Minerals	22.16	16.1	15.8	12.8	1.52
16	No Manure	18.10	16.3	16.0	13.3	1.45
17	400 lbs. Tankage	16.16	15.8	15.4	12.8	1.61
18	400 lbs. Tankage and Mixed Minerals	23.77	15.9	15.5	12.7	1.39
19	280 lbs. Fish Scrap	23.63	15.9	15.5	12.8	1.40
20	280 lbs. Fish Scrap and Mixed Minerals	22.47	15.2	14.8	11.8	1.68

*Mixed Minerals—430 pounds Acid Phosphate and 100 pounds Sulphate of Potash.